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Soil Quality Analysis for Dryland Agriculture with Variation of Fertilization and Plant Rotation in Argomulyo District, Salatiga City

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Abstract

The study aim is to analyze soil quality for dryland agriculture with variations in fertilization and plant rotation in Argomulyo sub-district, Salatiga city. This study took samples on dryland agricultural land in Ledok Village by taking sample points using random sampling with a cluster sampling pattern by dividing them into 4 clusters. The Step of the research are field and laboratory observation to know the soil pH and moisture, also to determine the soil value and cation test, respectively. Next is the interview step to know the effect of fertilization and plant rotation variation. This research uses quantitative description analysis techniques. Based on the field observation was obtained the cluster 2 has pH value around 6.5 in the category slightly acidic. Then, for cluster 1,3, and has 4 neutral pH category in the range 6.6 – 7.5. The humidity of clusters in the dry category is in the range of 0 - 30%. Laboratory observation shows cluster 3 has a lower resistance around 8.1KΩ and has the best cation exchange capacity (CEC) test compared with other clusters. Based on the results of interviews, cluster 2 received organic fertilization and crop rotation occurred. Clusters 1 and 4 have not received any planting activity since October 2020. Meanwhile, fertilization in cluster 3 uses inorganic fertilizers. So Cluster 2 soil quality is better than the other three clusters due to organic fertilization and plans rotation so that the soil nutrients become stable. Cluster 1 has poor soil quality due to variations in inorganic fertilization, neglecting the soil, and being planted *Manihot esculenta* which impacted the reduction in the amount of nitrogen and phosphorus in the land.

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INTRODUCTION

Argomulyo District is one of the districts in Salatiga city with densely populated. The area of agricultural land is only 1,853 ha (BPS, 2021) from the total area of 1,852,600 ha (Department of Population and Civil Registration, 2021). Based on data from the Central Bureau of Statistics on Land Use Area by District in Salatiga City in 2020, the area of agricultural land in Argomulyo District is 1,853 ha, is used for 9 ha of rice fields, 755 ha of dry land, and 1089 ha of other lands. It showed that in Argomulyo District, the use of dryland is greater than the use of paddy fields. Therefore, as a dryland agricultural area, it is necessary to maintain the quality of the soil to increase agricultural yields.

The ability of the soil to provide soil nutrients in a balanced amount is called soil fertility (Archana et al., 2021). Plant growth factors are not determined by soil fertility only, but it is necessary to pay attention to other environmental factors that affect plant growth. These factors include light, air temperature, humidity, and others that are can limit plant growth. The soil fertility level is closely related to the availability of soil nutrients. For plant growth, and limiting factors for plant growth (Purwanto et al., 2014). It is so important to know the nutrients for plants so it is necessary to assess the status of soil fertility to assess and monitor soil fertility (Rodelo-Torrente et al., 2022).

Various methods are applied to measure soil quality. However, the parameters used still refer to the chemical, biological, and soil physical properties (Nunes et al., 2021). The interactions between inherent soil properties, biological, physical, and chemical processes are complex, so soil quality must be measured when assessing soil quality. To facilitate such quantification across land use and management, practices an interpretive framework has needed that provides a wide selection of regionally relevant indicators (Wander et al., 2019).

Soil quality can be affected by variations in fertilization. The addition of manure can impact the increase in the adsorption capacity of Cu (II) and Cr (VI) metal ions in Andisol soil (Wijayanti et al., 2018). The results of a similar study showed that the application of 5 tons of organic fertilizer plus 50% of the recommended fertilizer with a combination of mycorrhizae could improve soil quality (Řezáčová et al., 2021). Changes in soil quality from the moderate status on soil without fertilizer to good criteria in the application of 50% inorganic fertilizer and 5 tons of organic fertilizer (Mamuye et al., 2021)

In addition to variations in fertilization, plant rotation can also affect soil quality. Plants rotation is an important tillage system in sustainable agriculture (Suprihatin et al., 2018). Plants rotation can increase the amount of nitrogen, water, and nutrient retention, reduce the need for inorganic fertilizers through planting legumes (de Notaris et al., 2018). Rotation with fava beans two years before wheat modifies microbial habitat in soil. Microbial activity can provide sufficient carbon, nitrogen and make the soil pH suitable(Malik et al., 2018). Plants rotation is a suitable practice, to increase microbial activity in agricultural land (Aschi et al., 2017). The application of long-term plants rotation has a significant effect on changes in soil chemical properties such as pH, total N, P, K, soil CEC, and organic C (Suprihatin et al., 2018).

The use of dry land which is quite extensive and diverse, especially in the agricultural sector, will certainly have a major influence on the value of soil quality in the area. Soil cultivation that does not pay attention to soil sustainability will result in soil damage (Frasetya et al., 2016). In order to increase the productivity of dryland agriculture in Argomulyo District, it is necessary to conduct research on the Analysis of Agricultural Soil Quality for Dry Land with Fertilization Variations and plant Rotation in Argomulyo District, Salatiga City, Central Java. The purpose of this study was to analyze the quality of dryland agricultural soil with differences in fertilization patterns and plant rotation patterns so that it can be used to evaluate fertilization patterns and dryland plant rotation in Argomulyo District, Salatiga City.

METHODS

The scope of the research is agricultural land on Jl. Argo Kartiko, Ledok Village, Kec. Argomulyo Salatiga City with geographical location 7° 20' 48.5“to 7° 20' 41.3" south latitude and 110° 30' 52.5" to 110° 30' 59.2" east longitude. Parameters in this research are soil pH, soil moisture, soil resistance, and cation exchange capacity (CEC). Individual sampling was carried out on agricultural land covering an area of 14,338.68 m^2 in the Ledok sub-district by taking a square field approaching 120m × 120m. Sampling points using random sampling with a cluster sampling pattern. Soil for representatives of each cluster has made a 30m × 30m pattern, as shown in Figure 1.

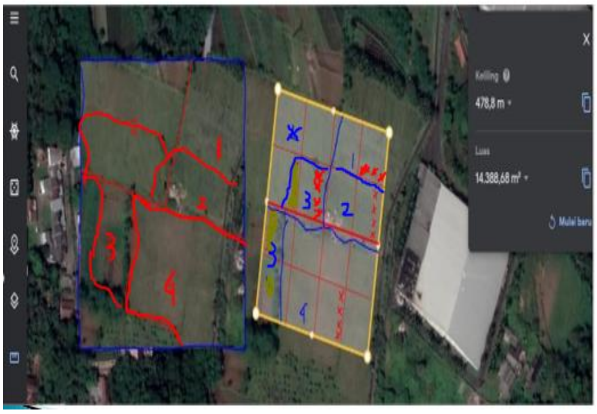

Figure 1: Determination of Sample Points

The tool used in this research is the Soil Meter VT 05 to measure pH and soil moisture. Individual soil was taken at a depth of 30 cm with a soil drill, hoe, and machete, then put into a labeled plastic bag (Balai Besar Litbang Sumber Daya Lahan Pertanian, 2006). In this test, each individual soil was weighed 250 grams using a Nankai ART 177-16 scale and then stirred with 75 ml of water. A mixture of water and individual soil samples was measured for soil resistance using a Multimeter type Aiwa - 360TRE-LB while the level of soil cations was tested with a simple cation test apparatus.

Data collection was carried out by means of observation and interviews. Observations were made to determine the quality of the soil with the parameters of soil pH, soil moisture, soil resistance, and CEC. While the interview method is used to determine the history of fertilization and plan rotation.

Descriptive analysis of pH, soil moisture, obtained compared with soil quality parameters. These parameters can be shown in Table 1.

Table 1. Soil Evaluation Parameters (Technical Instructions for Evaluation of Soil Fertility from PPT. (1995)

No	Parameter	Value	Criteria
1	pH	<4.5	Very sour
		4.5 – 5.5	Sour
		5.6 – 6.5	Slightly sour
		6.6 – 7.5	Neutral
		7.6 – 8.5	Slightly alkaline
		8.5	alkaline
2	Soil moisture	0-30%	Dry
		30-70%	Moist
		70-100%	Wet

Parameters Cation exchange capacity can be seen from the electrical conductivity. Good cation exchange capacity value was indicated with higher electrical conductivity. Meaning that the lower the value of the soil resistance, the higher the electrical conductivity and the high cation exchange capacity, which reflected soil fertility (Tang et al., 2020)

RESULTS AND DISCUSSION

Data from observations of pH, humidity, resistance, and soil cation tests can be shown in Table 2.

Table 2. Data on pH, Humidity, Resistance and Soil Cation Test

Cluster	Sample	pH of soil	mean of pH	Soil Humidity	Mean of Humidity	Resistance/ Z (kΩ)	mean of Z (kΩ)	State of ligh
1. Damatex 1	1	6.8	6.75	10%	11.25%	25.2	22.4	off
	2	6.8		10%		21.2		off
	3	6.6		15%		25.2		off
	4	6.8		10%		18.0		off
2. Citizen's land	1	6.4	6.50	20%	17.50%	8.8	8.1	dim
	2	6.4		20%		8.0		light
	3	6.6		15%		8.6		dim
	4	6.6		15%		7.0		Very light
3. Crooked Land	1	6.8	6.65	10%	13.75%	12.0	9.7	off
	2	6.6		15%		10.4		off
	3	6.6		15%		8.4		light
	4	6.6		15%		8.0		light
4. Damatex 2	1	6.8	6.70	10%	13.33%	10.0	9.15	off
	2	6.8		10%		8.0		light
	3	6.6		15%		9.4		Tungsten glows
	4	6.6		15%		9.2		Tungsten glows

Soil pH Analysis

Based on Table 2 about mean of pH, It can be seen that the highest pH in Cluster 1 is in the slightly acidic category, while Clusters 1, 3, and 4 can be a category as neutral pH. Based on the soil pH category, it can make estimated that there is good soil nitrogen(N)-fixing bacteria activity in the four clusters. The content of N, such as nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+). It is an urgent parameter of N in soil fertility. The protoplasm Nutrient N is a constituent of 40-50 percent. There is the main component of protein, hormones, chlorophyll, vitamins, the enzymes of crops, and stimulates a plant's vegetative growth (Taisa, 2021). The availability of nutrients for plants exerts an influence on soil pH. The effect of pH on the availability of Nitrogens is related to nitrogen-fixing bacteria, which are sensitive to pH. The soil has an acidic pH that will inhibit the activity of nitrogen-fixing bacteria (Scarlett et al., 2021).

Soils that have a pH > 6 contain Potassium (K), Calcium (Ca), and Manganese (Mg), widely available in soils (Barker et al., 2020). The Soils are in the acid category undergo to be weathering, and soil leach so that the K, Ca, and Mg elements are lost. Soils have a pH of 5.5 - 6.8 is abundant in phosphorus (P). The pH<5.8 are soils become unavailable because P make bound by Fe and Al. Elemental P is not available to plants at pH > 6.8 because P is bound by Ca (Barker et al., 2020). Soil nutrients such as Potassium(K), Calcium (Ca), and Manganese (Mg) make estimated from the soil pH value (Rianida Taisa, 2021). The pH value of the four Clusters is 6 < pH < 6.8, it analyzed that the four soil clusters have good nutrient content. These nutrients are K, Ca, and Mg, which were became found in the top layer at a depth of < 30 cm.

Soil Moisture Analysis

The results showed that Cluster 2 had the highest soil moisture reaching 17.5 percent, and Cluster 1 had the lowest at soil moisture at 11.25 percent. Based on Table 2, the four clusters have the same relative humidity and categories as dry humidity. It is possible because this research was presided over in October 2021 with low rainfall.

Soil moisture is related to soil porosity. This soil porosity is the proportion of soil pore space contained in a volume of soil that it can make occupied by water and air (Balashov et al., 2021). The existence of these soil pores makes the soil pores able to absorb water and support plant growth. Dense soil has little pore space, and dense soil has little soil porosity (Taisa, 2021). It makes analyzed that Cluster 2 has the best porosity among other clusters. Cluster 2 soil is looser, which means the soil has more pore space for water and air. It is possible for Cluster 2 can get good soil management and irrigation system compared to the other three Clusters.

All research clusters in the dry humidity criteria were possible due to the low rainfall during the study and the lack of soil N content. Soil moisture is one of the factors so that the N content of the soil is maintained (Ouyang et al., 2017). Thus, farmers need techniques and creativity to keep alive the soil moisture even though the rainfall is low.

Electrical Resistance Analysis and CEC

The method measuring electrical conductivity with electrical resistance is an approach that uses multitester that can make developed in determining the quality of agricultural land (Adirianto et al., 2021). Based on Table 2, it is can found that Cluster 1 has the highest resistance value seen from all individual samples not turning on the indicator light for a simple cation test instrument. The lowest obstacle is Cluster 2, which are can see by the light on the cation test. It indicates Cluster 2 can make the light on the cation test. These suggested that Cluster 2 has CEC, better electrical conductivity, possibly more alkaline cations such as Ca, Mg, K, and Na than other clusters. On the other hand, Cluster 1 has the highest soil resistance, so the CEC is small and the level of soil fertility is lower than the other Clusters.

An approach for measuring the value of electrical resistance can identify. The value of Electrical Conductivity (DHL). The value of electrical resistance will be inversely proportional to the value of DHL. Electrical conductivity is closely related to CEC. CEC is a chemical property and closely soil fertility. Soils with a high CEC are better able to trap and provide nutrients than soils with a low CEC. Soil with high CEC can estimate dominated by basic cations Ca, Mg, K, and Na (high base saturation). It can increase soil fertility but, its domination by acidic cations, Aluminum (Al), and Hydrogen (H) with low base saturation can reduce fertility land. Because the nutrients are present in the colloid absorption complex, these nutrients are not easily washed off by water (Taisa, 2021)

Results of the interview regarding variations in fertilization and crop rotation of all the clusters as shown in Table 3.

Table 3. Data on Fertilization Variations and plant Rotation

State	C1	C 2	C 3	C4
Fertilizer type (last 6 months)	An organic	Organic	An organic	Organic dan an organic
Fertilizer	urea	Chicken feathers, cow dung	Urea	Chicken manure and urea
Fertilization end time	October 2020	October 2021	September 2021	October 2021
Last time planted	October 2020	October 2021	September 2021	October 2020
Final crop type	*Manihot esculenta*	Mustard greens, spinach	Corn plant	chili plant

Cluster 2 and Cluster 3 soils received similar treatment. They both underwent crop rotation and fertilization, but the difference is from the type of fertilization given. Cluster 2 and 3 are in the dry humidity category, while the pH of the two clusters is a difference of 0.15. It said that both are identical in humidity and pH parameters. Another difference in Cluster 2 and 3 founded in the soil resistance and the results of the cation exchange test. The results are the Cluster 2 soil resistance measurement is lower than Cluster 3 soil resistance. The results of the cation test of individual Cluster 2 samples can all turn on the indicator light of the cation test instrument. The Individual samples of Cluster 3 turn on the cation test indicator light for only two of the individual samples soil. Organic fertilization can affect the DHL, and CEC possibility reflects soil fertility. Soil with organic fertilization has a better fertility rate than soil fertilization with inorganic fertilizers. Organic fertilization causes the abundance of nutrients as evidenced by the cation test indicator light on.

Cluster 1 and Cluster 4 generally had the same soil treatment, namely for one year, they did not experience crop rotation and fertilization. The difference is that the last Cluster 1 was fertilized by inorganic and the final crop was cassava. Cluster 4 was fertilized to the inorganic and organic fertilizer, and the latest crop was chili. Based on the pH and humidity data are still in the category of neutral pH and dry humidity. Cluster 1 soil resistance values were higher, indicating that the DHL and CEC of Cluster 1 were lower than Cluster 4. It was possible because the fertilizer applied was inorganic fertilizer and the last crop was cassava. Cassava plants (*Manihot esculenta*) have the characteristics of releasing less N and P to the soil, but the elements of K, Ca, and Mg are comparable to other plants. The Soil essential elements such as N, P, K, S, B, Cu, Fe, and Zn, were found to limit the nutrients absorbed by cassava plants. Therefore, it is necessary to improve the limitations through balanced fertilization (Laekemariam, 2016).

CONCLUSION

The results as field observations show that Cluster 2 has a pH of 6.5, which is in the slightly acidic category, and Clusters 1.3 and 4 in the Neutral pH category (6.6 – 7.5), dry humidity (0-30%). The results as laboratory observations showed that Cluster 2 had the lowest resistance (8.1 kΩ) and the best cation exchange capacity (CEC) test.

Based on the parameters of pH, moisture, soil resistance, CEC in this study, it showed Cluster 2 has better soil quality than the other three Clusters. Organic fertilizer has impacted the fertility of the soil, and crop rotation occurs so that soil nutrients become stable. The soil quality is not good in Cluster 1 soil because the fertilizer given is inorganic fertilizer. There was neglected soil for one year, then N and P elements are low because cassava is last planted.

The results of this study recommended that fertilization can be done with organic fertilizers and always do crop rotation with a variety of legumes. Cassava plants should be planted in dry fields so that they do not interfere with soil nutrients used for dryland crop commodities.

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